ADDRESSING QUESTIONS ABOUT INCLUDING ENVIRONMENTAL EFFECTS IN THE DMSO HLA[*]
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ABSTRACT

The Defense Modeling and Simulation Office (DMSO) is developing a High Level Architecture (HLA) to support the DOD Modeling and Simulation (M&S) community. Many, if not all, of the simulations involve the environment in some fashion. In some applications, the simulation takes place in an acknowledged environment without any environmental functionality being taken into account.

The Joint Training Federation Prototype (JTFp) is one of several prototype efforts that have been created to provide a test of the DMSO HLA. In addition to addressing the applicability of the HLA to a training community, the JTFp is also one of two prototype efforts that is explicitly including environmental effects in their simulation effort. These two prototyping efforts are examining the issues associated with the inclusion of the environment in an HLA federation.

In deciding whether or not to include an environmental federate in the JTFp effort, a number of questions have been raised about the environment and the HLA. These questions have raised the issue of "incompatibility" between the environment and the HLA and also shown that there is "something" unique about including the environment in simulations. The purpose of this White Paper, which was developed with inputs from the National Air and Space [Warfare] Model Program among others, is to address the various questions that have been posed about including environmental effects in an HLA simulation.

1.0 "CAN THE ENVIRONMENT BE REPRESENTED IN AN OBJECT-ORIENTED FASHION?"

Yes. There are no technological reasons why the environment cannot be represented in an object-oriented fashion. All of the components that make up an environment, such as atmosphere, clouds, terrain, oceans, transportation networks, etc., are "things" that can be represented as objects. The various components can be assembled in a taxonomy and be expressed to whatever level of detail in the same way that any other component in a simulation can be expressed as a collection of objects. In terms of the objects used in an HLA federation, the various environmental objects can publish and subscribe to attributes. Ownership of environmental attributes could also be transferred to other federates. For example, an environmental attribute describing obscuration could be transferred to a federate that had the capability to generate and propagate battlefield obscurants.

2.0 "ARE THERE ANY UNIQUE REQUIREMENTS IMPOSED BY THE ENVIRONMENT ON AN OBJECT-ORIENTED SIMULATION?"

No. Including the environment can result in objects that are "large" in terms of the amount and complexity of the attributes (*e.g.* 3-D gridded data fields) required to describe them. However, these kinds of requirements are not unique to the environment - an engineering level simulation can require objects as complicated as those that might be needed in an environmental simulation. In fact, the representation of aggregate effects is aided rather than hindered in object oriented simulations.

3.0 "WHAT LEVEL OF ENVIRONMENTAL REPRESENTATION IS REQUIRED IN AN HLA SIMULATION?"

The level of environmental detail required (for any subject area) will be assessed and determined by the Federation members as a part of the FOM development process.

4.0 "IN AN HLA SIMULATION INCLUDING ENVIRONMENTAL EFFECTS, SHOULD THE ENVIRONMENT BE TREATED AS OBJECTS OR AS A COMMON SERVICE?"

How the environment, or any other simulation component, is represented in a Federation will be determined during the federation development process. If every member of a federation had the same internal methods of describing the environment and its interactions (*i.e.* within their individual SOMs) and the federation did not take into account any dynamic feedbacks between the simulation and the environment (*e.g.*, smoke from destroyed targets or craters from explosions), then there would be no need to have an environmental federate. However, doing so would limit the potential reusability of that

federation and thereby violate a primary goal of the HLA - to maximize reuse and promote interoperability. If a federation has environmental interactions that cross federation boundaries and/or if the simulation involves activities that can cause changes to the environment (*i.e.* dynamic environmental feedback), then the environment <u>must be</u> represented as objects and interactions at the FOM level.

Regarding the issue of incorporating "common" environmental services into the HLA, there are some aspects of the environment that could be common, but it is felt that additional study must be made in this area. Common coordinate services and transformations could be provided.

There has been discussion that line-of-sight (LOS) could be a common service, but while the "concept" of a LOS is simple, the implementation is not. For example, the wavelength region (*e.g.* visible versus infrared) and extent (*e.g.* narrow band versus broadband) involved must be considered as well as the potential impacts of curvature due to index of refraction variations (which are also wavelength dependent.)

In the real world, LOS is best represented as an HLA interaction. First, it is unlikely that a definition could be agreed to that would satisfy all interested parties. Second, LOS can be affected by dynamic changes in the simulation including dynamic environmental alteration (*e.g.* smoke, battlefield obscurants, dust generated by vehicles, damage to platforms or buildings, etc.) that by definition will involve interfederate object interactions.

5.0 "IF COMMON SERVICES IN <u>ANY</u> <u>SUBJECT DOMAIN</u> (*e.g.* ENVIRONMENTAL, FORCE, OR BEHAVIORAL REPRESENTATION) CAN MEET THE
NEEDS OF A SPECIFIC FEDERATION, SHOULD THE SERVICES BE PROVIDED AS AN AMG-APPROVED SET OF SERVICES OR AS A SET DEVELOPED BY THE FEDERATION TO MEET THEIR UNIQUE NEEDS?"

Seeing that the needs for common services will be based on the needs of a given simulation community represented within a federation, it is felt that it is unlikely that a set of common services that would be encompassing enough to meet the anticipated needs of all users could be developed. Therefore, it is felt that it would be more prudent to enable the RTI to incorporate any set of common services that a given federation determined was necessary.

6.0 "DOES EVERY FEDERATION WITH ENVIRONMENTAL INTERACTIONS HAVE TO HAVE A SEPARATE ENVIRONMENTAL 'LOLLIPOP'?"

Not necessarily. If one member of a federation had a fully robust environmental representation as a part of its simulation system, it conceivably could handle all of the environmental needs of the entire federation. The FOM development process would provide the logical mechanism to determine what is required.

7.0 "IF AN ENVIRONMENTAL LOLLIPOP IS INCLUDED, WHAT LEVEL OF ENVIRONMENTAL OBJECT STRUCTURE IS REQUIRED?"

The level of environmental class structure required will be determined during the FOM development process. As with any federation, only those objects and interactions required should be included in the FOM. Also, an environmental federate may have a richer class structure at the SOM level than that included at the FOM level.

8.0 "CAN PUBLICATION OWNERSHIP CONTROL OF ENVIRONMENTAL ATTRIBUTES BE PASSED TO OTHER FEDERATES IN A SIMULATION?"

Yes. As long as there is a logical connection between a federate and any attribute, publication ownership control can be passed. In the case of environmental attributes, an artillery platform could control the creation of craters in the ground, a ship could control the creation of wakes in the ocean, or an aircraft could control the production of contrails in the atmosphere.

9.0 "CAN ENVIRONMENTAL OBJECTS BE AGGREGATED OR DISAGGREGATED?"

Yes. Environmental objects can be represented at whatever level-of-detail (spatial or temporal) that is required. In a simulation involving sensor performance, individual clouds or aggregated cloud fields could be represented.

10.0 "CAN ENVIRONMENTAL OBJECTS BE FILTERED?"

Yes. Federates could subscribe to environmental objects with different kinds of filters in place. For example, an aircraft could subscribe to only those clouds within a certain radius (*i.e.* a sensor effectiveness range) around the aircraft or a ground vehicle could subscribe to only those terrain attributes along a projected route.

11.0 "DOES THE HLA OFFER ANY ADVANTAGES OVER DIS IN TERMS OF DEALING WITH THE ENVIRONMENT?"

Yes. The HLA offers two primary advantages over DIS in terms of dealing with the environment. The first advantage is that using the HLA enables one to be able to provide the environmental data and interactions tailored to each federate's needs rather than having to transmit all environmental data and requiring that each member listen for, find, and then tailor the data to meet their needs. The second advantage is that the HLA frees one up from the restrictive nature of DIS's Protocol Data Units (PDUs). Seeing that the DIS community has not agreed on how to formulate a set of "environmental" PDUs, this advantage is significant.

12.0 "DOES THE HLA OFFER ANY DISADVANTAGES OVER DIS IN TERMS OF DEALING WITH THE ENVIRONMENT?"

Based on the current implementation of DIS, no. However, it is noted that the DIS community has extensive experience in the *visualization* of environmental phenomena.

13.0 "COULD THE INCLUSION OF ENVIRONMENTAL EFFECTS IN A FEDERATION LEAD TO PERFORMANCE IMPACTS WHEN USING THE HLA?"

Yes, but the performance impact is a result of the requirements and goals set for the federation and the scenario, not because of the presence of an environmental federate. If a simulation scenario requires high levels of detail from any simulation component, there is a likely performance penalty. What this translates to in terms of the Federation Object Model development process is that a costs/benefits analysis will have to be performed to determine what levels of detail are absolutely required and then agree on what subsequent performance penalty hits are "acceptable." However, it is again stressed that this would have to be performed for all

components in a federation, not just the environment.

14.0 SUMMARY AND CONCLUSIONS

In "real world" military applications, the environment can be a crucial, and even a decisive, factor. Military forces can utilize the environment as a force multiplier (via the use of all weather aircraft or night vision equipment) or be adversely impacted by it (as witnessed by the many Eastern European campaigns.) One of the first public comments made after NATO forces began their aerial campaign this past fall in the former Yugoslavia was that weather prohibited many aircraft from hitting their assigned targets. A "real world" fact is that the environment is an important factor in military operations. As a result, any DOD modeling and simulation program needs to be able to adequately include environmental factors to a level appropriate to the problem being addressed.

The DMSO HLA has been designed to offer a new and improved simulation architecture for the DOD M&S community. A number of questions have been raised about whether or not the environment can be adequately handled in an HLA simulation and if their are any unique aspects of the environment that render it incompatible with the HLA. This White Paper has addressed the various questions that have been raised about the environment and the HLA and demonstrated that there is nothing unique about the environment in terms of modeling it in an object-oriented fashion and that there are no incompatibilities between modeling the environment and the use of the HLA. In addition, we have demonstrated that questions related to the level of modeling detail required and potential impacts on performance relate to any subject domain modeled and not just the environment.